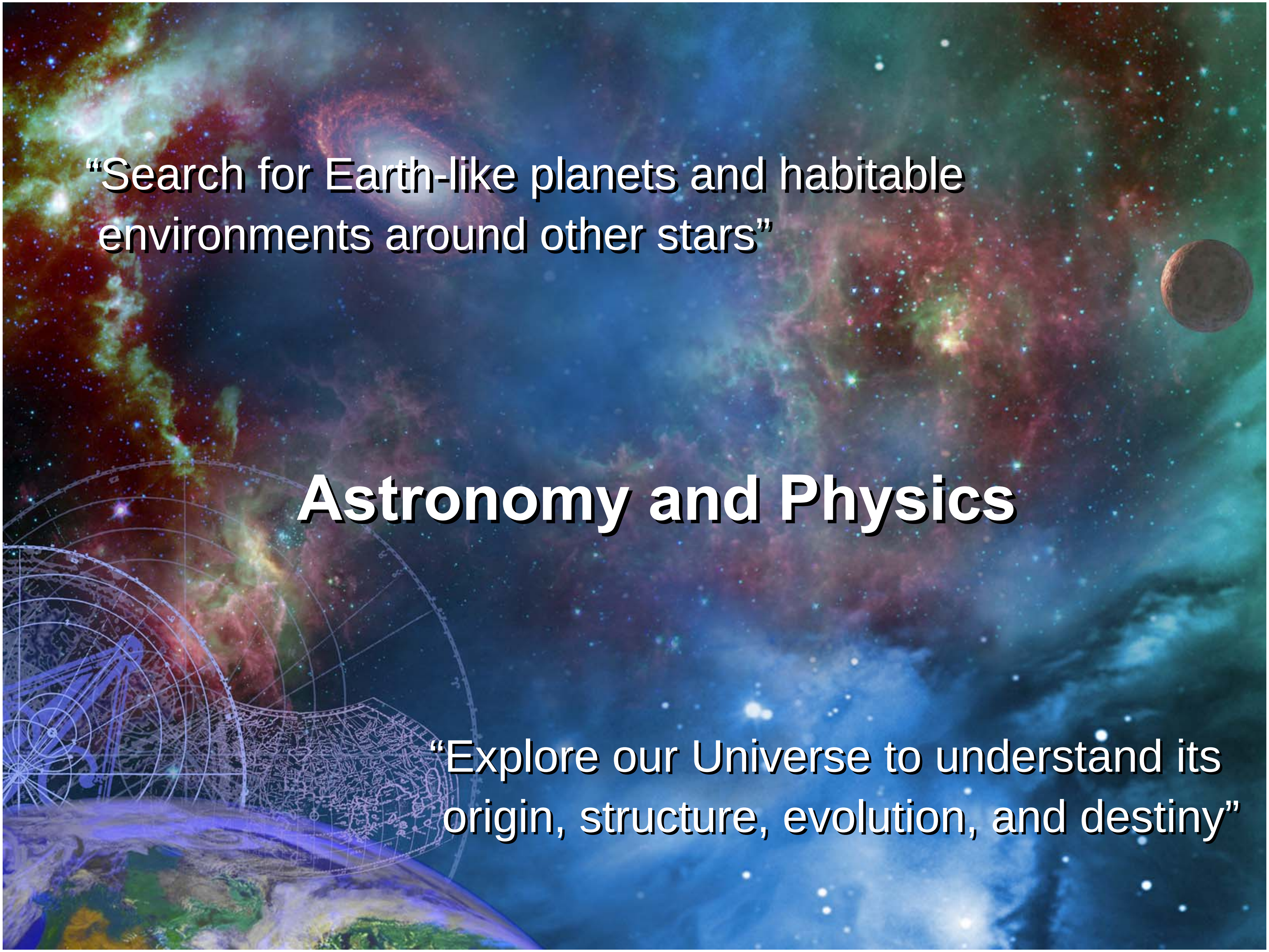
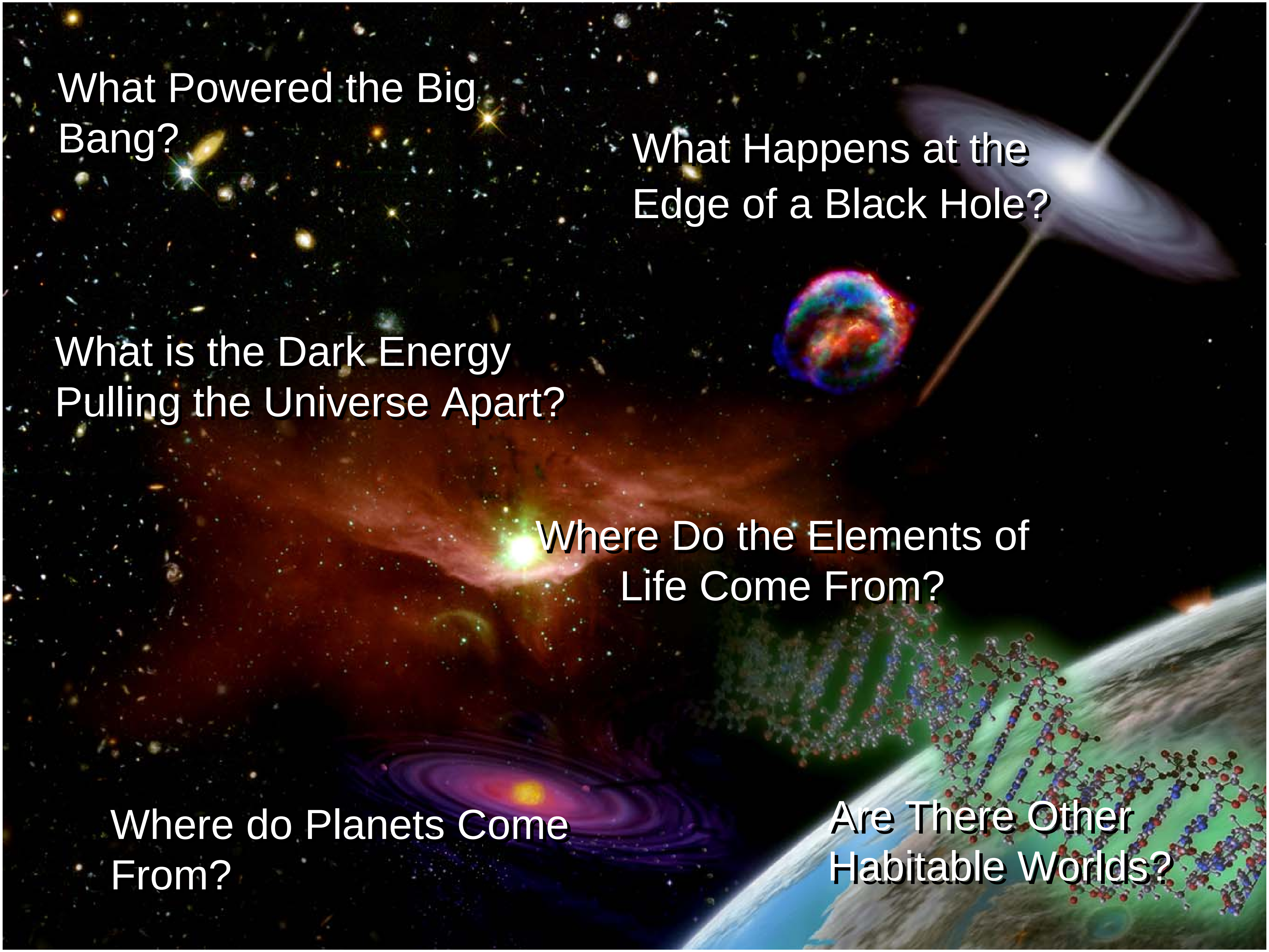

Science Mission Directorate
NASA Science
NASA
November, 2005


Where do we come from?
Where are we going?
Are we alone?

The Advance of
Science at NASA
WE WILL BE...
WE ARE...
WE WERE...
LONGWAVE RADIATION
ERBS + NOAA 9 APRIL 1985
PROC: 6-30-89 hgmo
NO DATA 100 200 250 300 350
WATTS / METER^2


"Search for Earth-like planets and habitable environments around other stars"
Astronomy and Physics
"Explore our Universe to understand its origin, structure, evolution, and destiny"

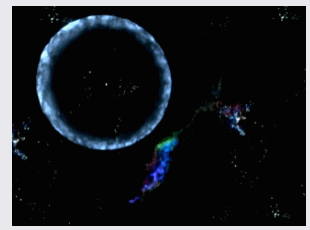

What Powered the Big Bang?
What Happens at the Edge of a Black Hole?
What is the Dark Energy Pulling the Universe Apart?
Where Do the Elements of Life Come From?
Where do Planets Come From?
Are There Other Habitable Worlds?

Recent Universe Highlights

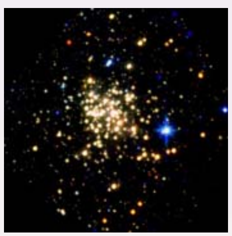
- **Chandra** sees giant x-ray flares from young stars that may aid in forming solar systems

- **Spitzer** detects the first true light from extra-solar planets

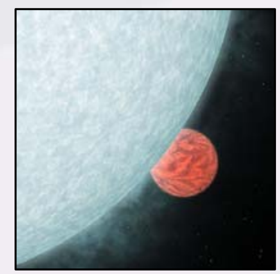
- **Spitzer** sees signs of an alien asteroid belt



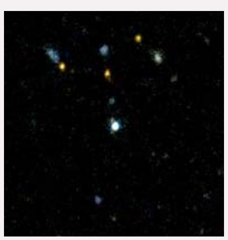
- **Hubble** confirms weight limit for stars



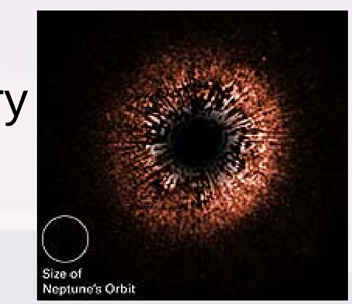
- NASA satellites, including **Swift**, observe one of the brightest known cosmic explosions



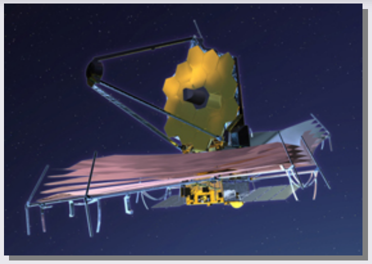
- **GALEX** finds massive baby galaxies in the nearby adult universe



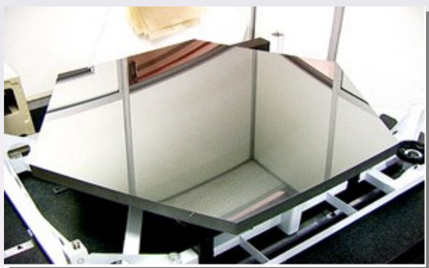
- **Spitzer & Hubble** capture views of evolving planetary systems



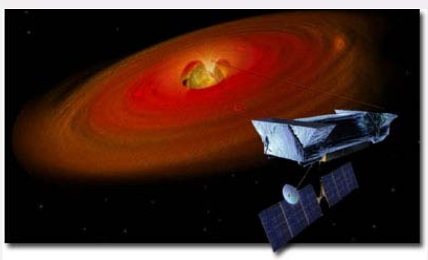
Astronomy & Physics Technology Priorities



Advanced infra-red and X-ray detectors will enable the search for Earth-like worlds and the study of the most energetic objects in the universe.



Large (4-10 diameter) lightweight mirrors and telescope systems to understand the processes of star, planet, and galaxy formation.



Large, lightweight, deployable structures will enable large telescopes to be packaged and launched by future launch vehicles.

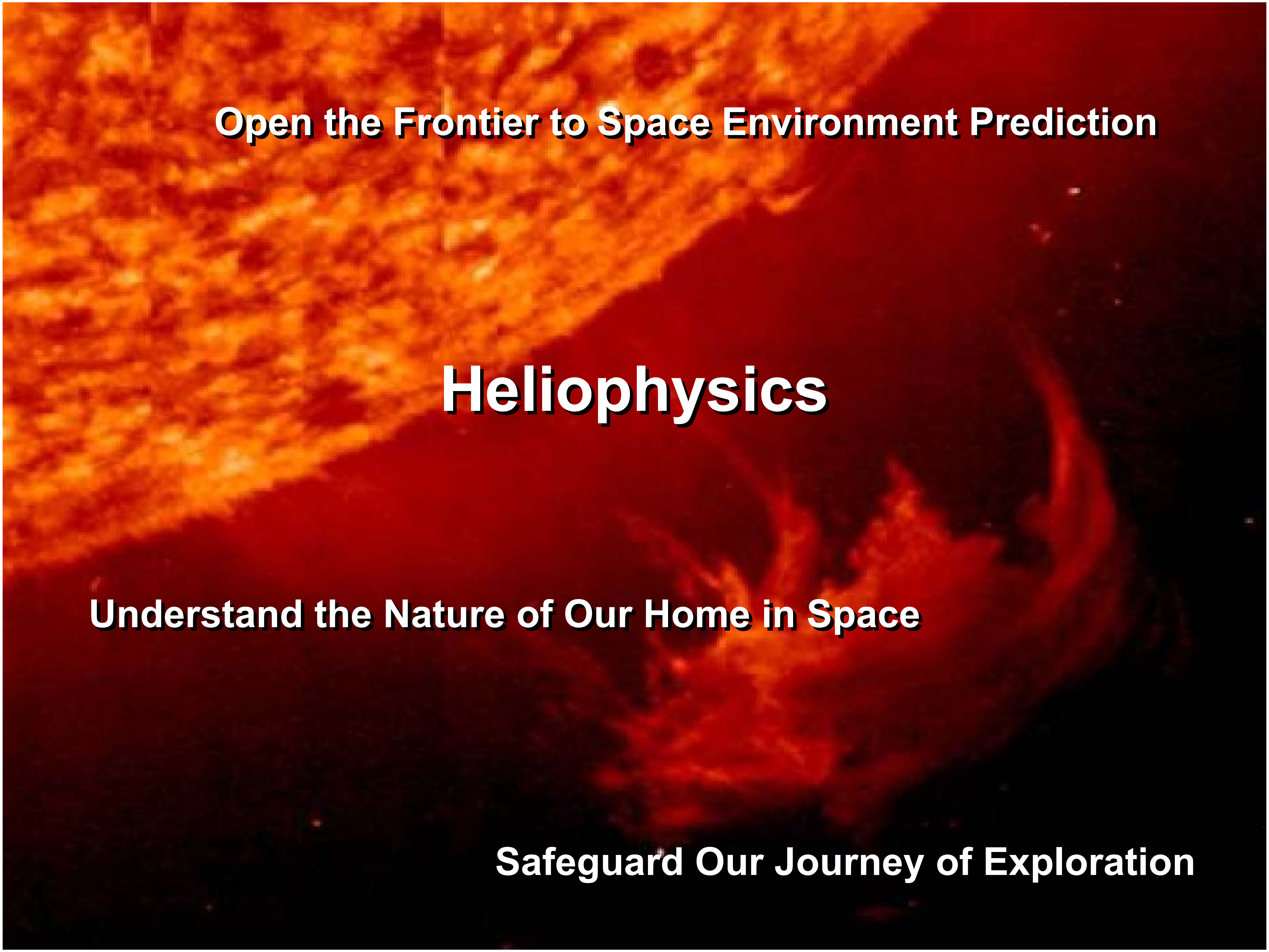
Precision formation flying is key to long baseline space interferometry.

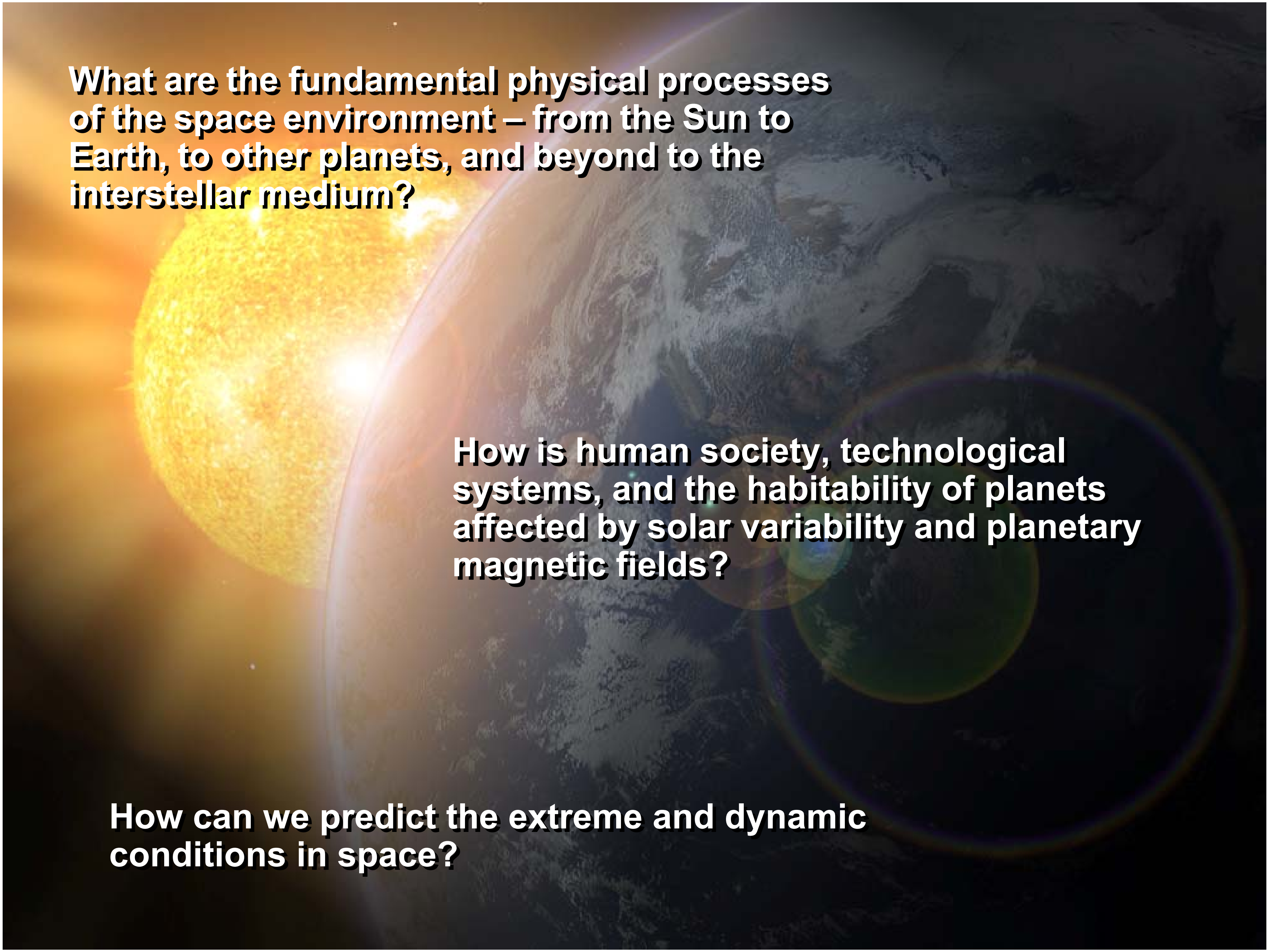
Astronomy & Physics Hot Topics

New community roadmap forthcoming

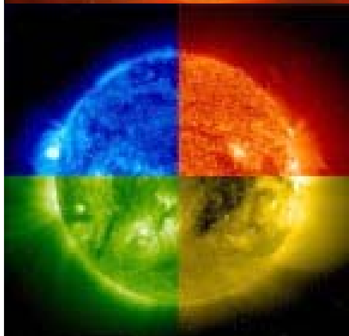
Managing cost and technical challenges in key missions:

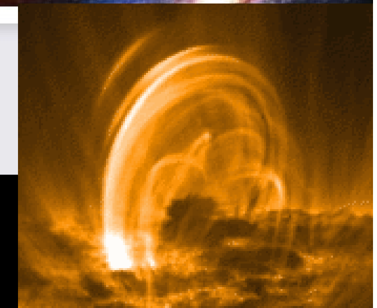
- James Webb Space Telescope (JWST): cost growth
- Hubble Space Telescope (HST) servicing: schedule uncertainty
- Stratospheric Observatory For Infrared Astronomy (SOFIA): continued delay in first flight
- Space Interferometry Mission (SIM): delay in project

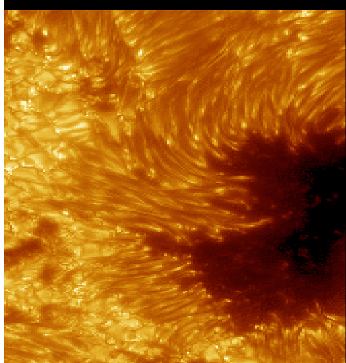

Open the Frontier to Space Environment Prediction
Heliophysics
Understand the Nature of Our Home in Space
Safeguard Our Journey of Exploration

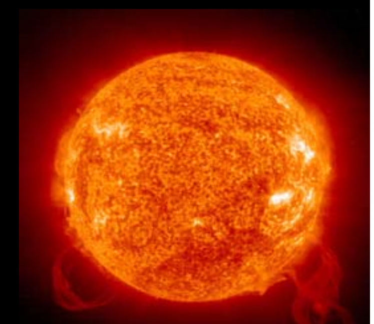

What are the fundamental physical processes of the space environment – from the Sun to Earth, to other planets, and beyond to the interstellar medium?
How is human society, technological systems, and the habitability of planets affected by solar variability and planetary magnetic fields?
How can we predict the extreme and dynamic conditions in space?

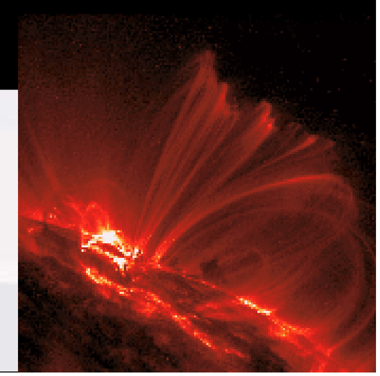
Unraveling the Mysteries of our Sun









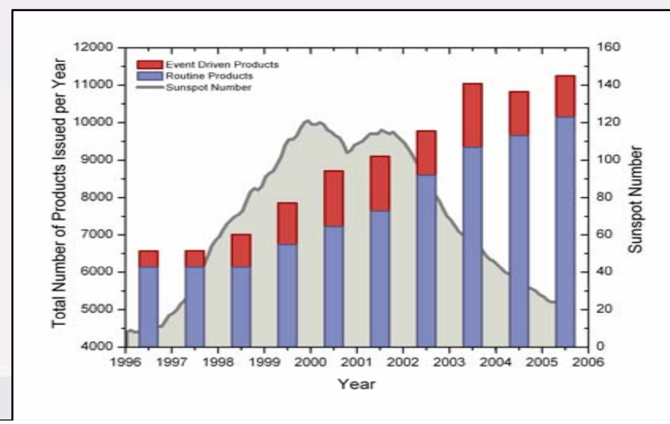


Recent Heliophysics Highlights

Voyager 1 spacecraft has entered the solar system's final frontier

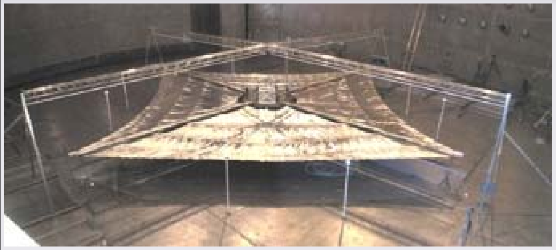
A major improvement in our ability to image the far side of the Sun has resulted from better interpretation of the signal from waves that have a multiple internal reflections as they travel around the sphere.

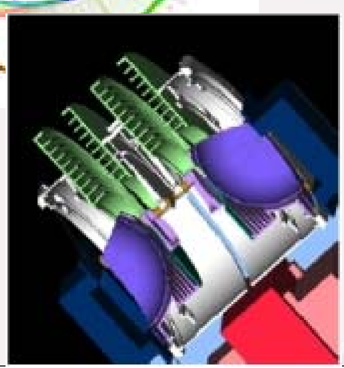
Growing number of users and products in space weather



YUV420 codec decompressor
are needed to see this picture.

Heliophysics Technology Priorities





High-ΔV propulsion and deep space power will permit access to unique vantage points

Spacecraft clusters and constellations will permit large area coverage and simultaneous in-situ measurements

Next generation Deep Space Network to return large data sets from throughout the solar system

Advanced modeling and simulation will permit analysis and visualization of space plasma

Heliophysics Hot Topics

New community roadmap forthcoming

Solar Terrestrial Probes (STP):

- Proceeding with MMS - highest priority in NRC decadal survey
- Will move out on next STP missions as resources permit

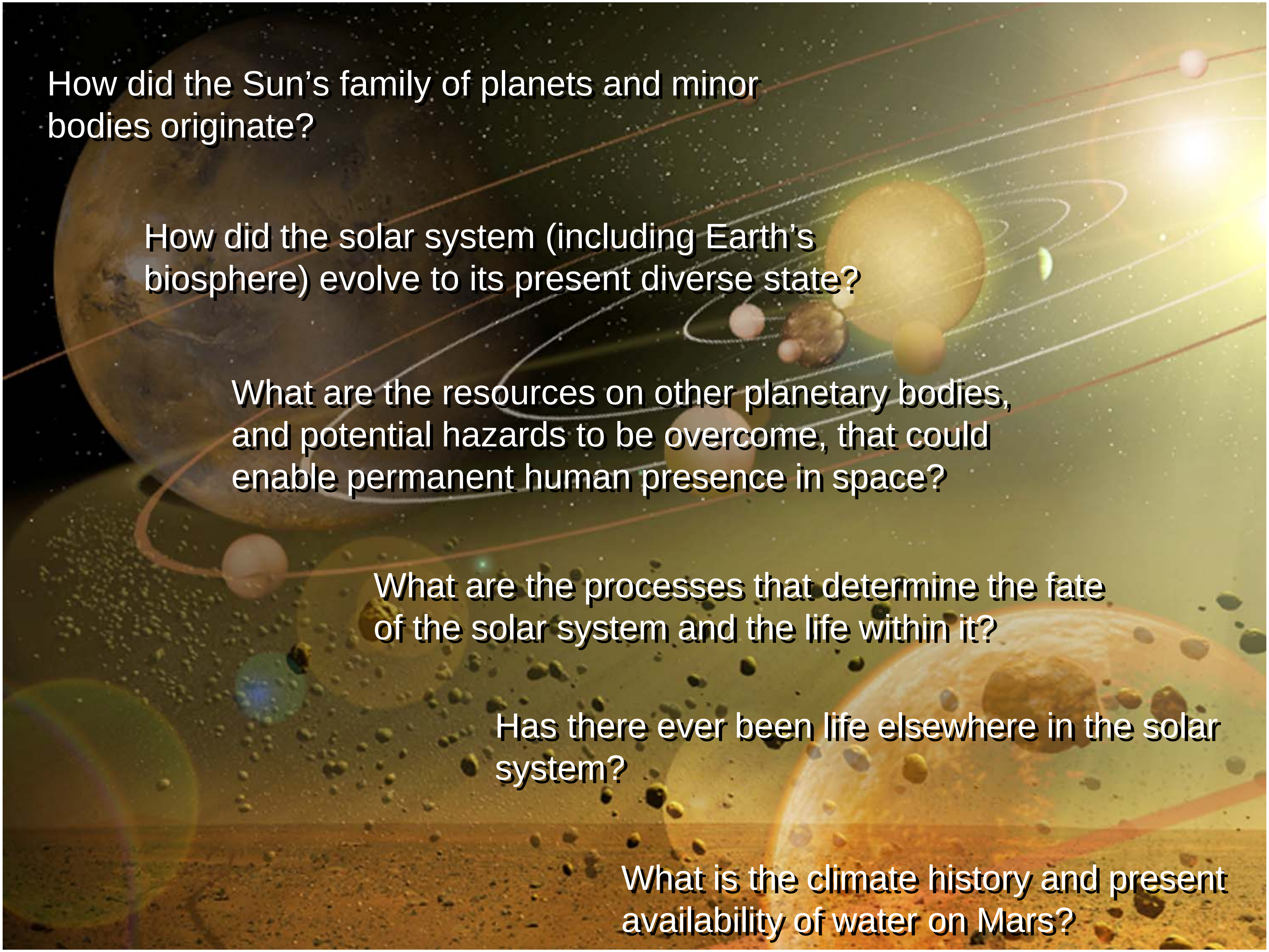
Explorers:

- IBEX and WISE selected for development
- Future mission rate challenged in the near term

Robotic exploration across the solar system to search for evidence of life, to understand the history of the solar system, to search for resources, and to support human exploration

Planetary Science

Exploration of Mars, including robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration


How did the Sun's family of planets and minor bodies originate?
How did the solar system (including Earth's biosphere) evolve to its present diverse state?
What are the resources on other planetary bodies, and potential hazards to be overcome, that could enable permanent human presence in space?
What are the processes that determine the fate of the solar system and the life within it?
Has there ever been life elsewhere in the solar system?
What is the climate history and present availability of water on Mars?

Mars Exploration Rovers

View From Spirit

View From Opportunity

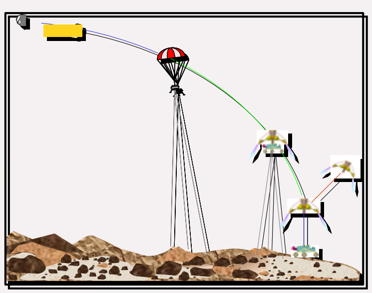
Deep Impact Encounter with Comet Tempel 1

Planetary Technology Priorities

In-space propulsion will reduce trip times, increase scientific payloads, and allow precision access to scientifically important vantage points

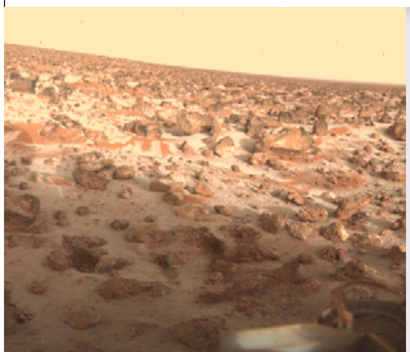
Autonomous systems and advanced Entry, Descent and Landing will permit precision targeting of scientifically important locations and efficient mobility across and below planetary surfaces

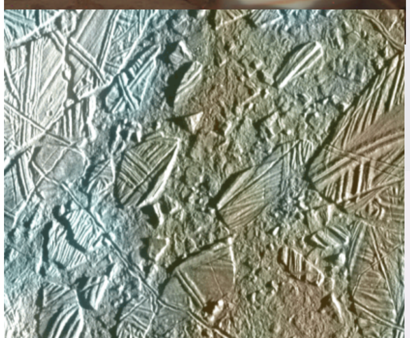
Instruments and avionics for extreme environments are essential in the environment of the outer Solar System, the surface of Venus, and close to the Sun.



Planetary protection systems and instruments for the search for life together will enable uncontaminated investigations into life's origins and precursors on Mars, Europa, and other worlds in the outer Solar System

Planetary Protection





Terrestrial biological contamination can compromise evidence of extraterrestrial life

- Could destroy answers central to NASA's scientific mission, and which are of historical human significance

We need to protect the Earth against the introduction of extraterrestrial life, if it exists

- Simple prudence; Complies with the 1967 Outer Space Treaty
- Future explorers must be protected against potential hazards (informed consent; "War of the Worlds")
- Measures must be appropriate, and adequate (ignorance is not bliss)

PP requirements are imposed on robotic missions now; Will likely affect future human missions to Mars

- Constraints based on current scientific understanding about target bodies and Earth life—knowledge of both components is increasing
  - Restrictions on spacecraft operating procedures
  - Inventory and sampling of organic material carried by missions
  - Reduction of biological contamination on the spacecraft (e.g., *Viking*)
  - Restrictions on handling of extraterrestrial samples returned to Earth
- Can be difficult to apply successfully; May be expensive to implement
  - Other USG and international space agencies face similar challenges
- Overall success requires long-range planning and near-term action

Planetary Science Hot Topics

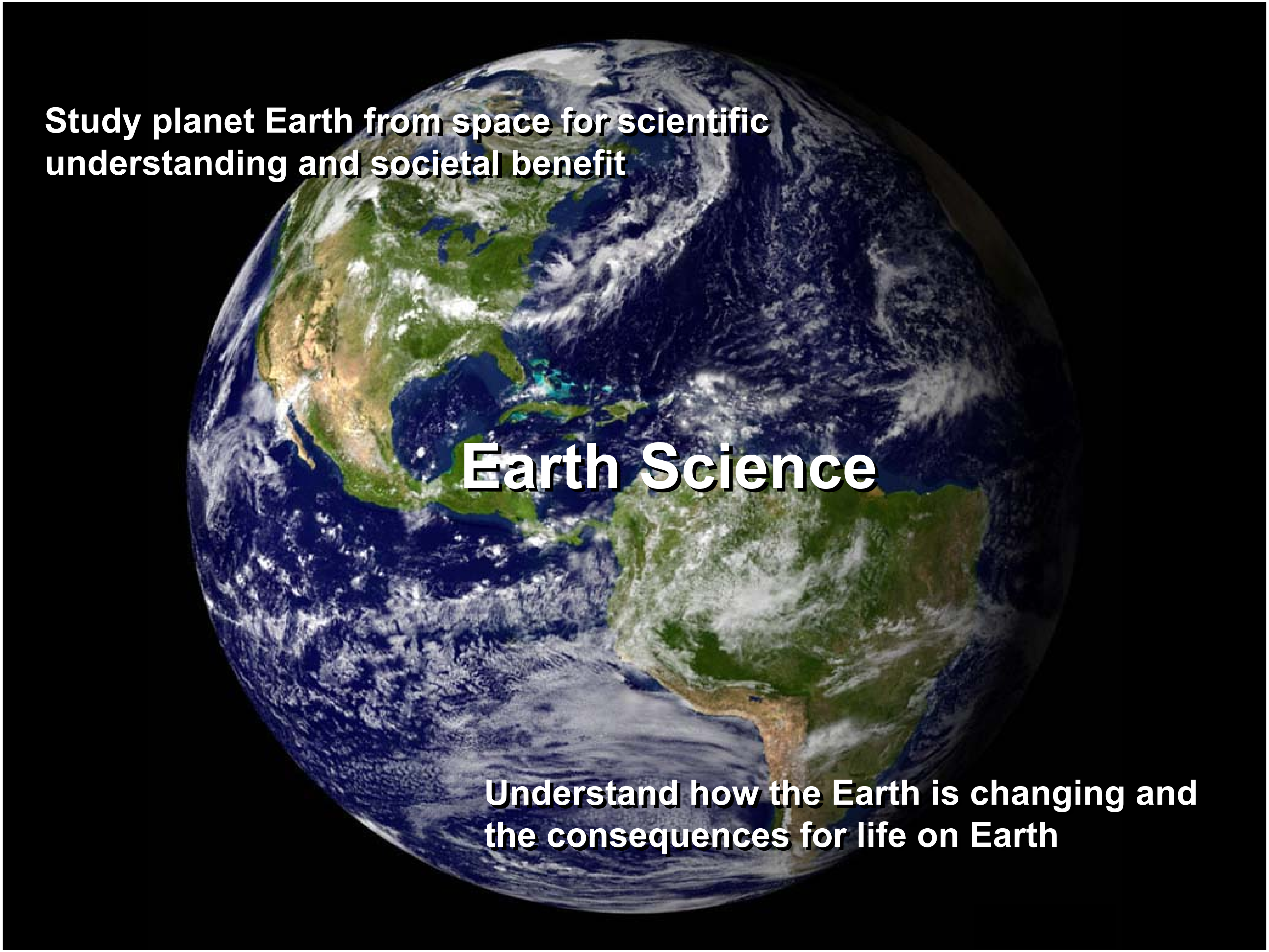
Discovery: balancing solicitation schedule with current mission cost growth

AO release planned for December

Mars program: reducing the outyear growth rate to rebalance the SMD portfolio; current MEPAG planning effort will help assure highest priorities

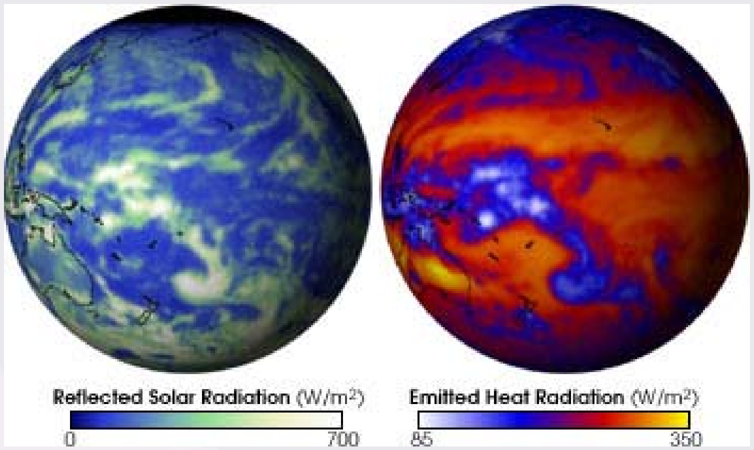
Draft Mars Scout AO planned for release in December for comment

Outer planets program: is it still Europa?


Study planet Earth from space for scientific understanding and societal benefit
Earth Science
Understand how the Earth is changing and the consequences for life on Earth

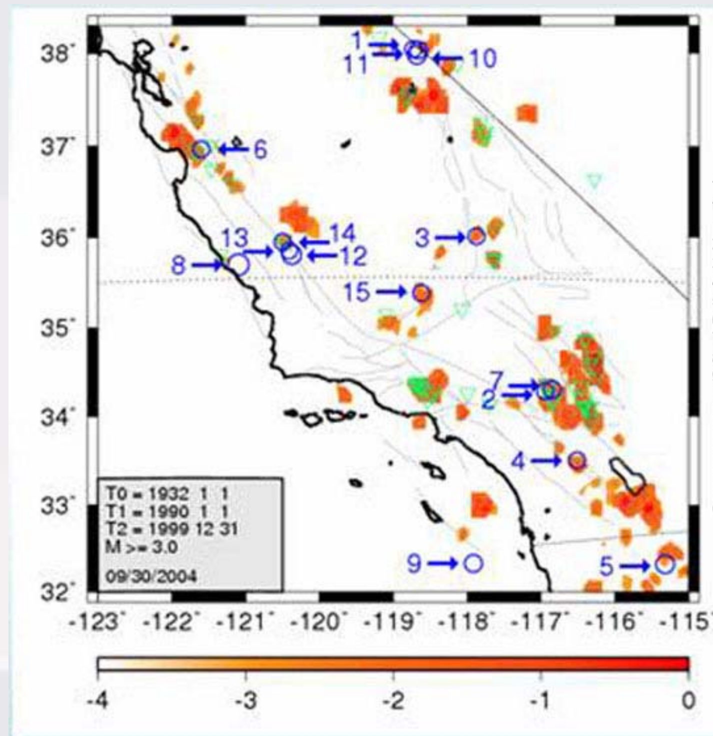

How is the global Earth system changing?
What are the primary causes of change in the Earth system?
How does the Earth system respond to natural and human-induced changes?
What are the consequences of change for human civilization?
How will the Earth system change in the future?

Recent Earth Science Highlights

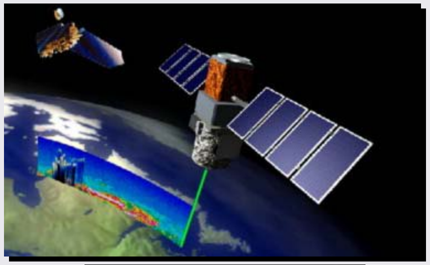


Of 16 earthquakes, magnitude 5 and higher since Jan. 1, 2000, 15 fall on “hotspots” identified by the forecasting approach developed by John Rundle at UC Davis

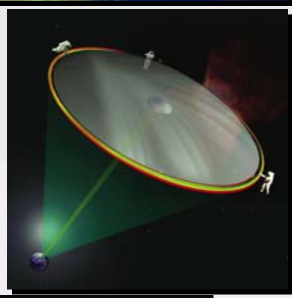
Scientists have concluded more energy is being absorbed from the sun than is emitted back to space, throwing the Earth's energy "out of balance" and warming the globe.



Earth Science Technology Priorities

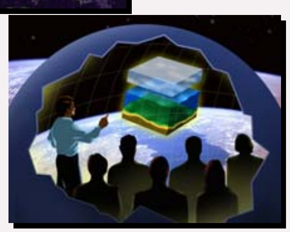


Active Remote Sensing Technologies to enable atmospheric, cryospheric and earth surface measurements



Large Deployables to enable future weather/ climate/natural hazards measurements

Intelligent Distributed Systems using advanced communication, on-board reprogrammable processors, autonomous network control, data compression, high density storage



Information Knowledge Capture through 3-D visualization, holographic memory and seamlessly linked models.

Earth Science Hot Topics

- Challenges in NPOESS program leading to impacts on the NPOESS Preparatory Project
  - Factors into on-going assessment of LCDM implementation strategy
- NRC Decadal Survey
  - Agency implementation of Interim Report recommendations
  - NRC effort to integrate priorities for the final report
- NASA/NOAA partnership to achieve research and operations transitions

Science Mission Directorate Flight Programs

- **Solar System Exploration (7)**
  - Cassini
  - In Space Propulsion Tech
  - Robotic Lunar Exploration
  - New Frontiers
  - Mars Exploration
  - Discovery
  - Radioisotope Power Systems & Tech
- **Earth Sun Systems (9)**
  - Living with a Star
  - Solar Terrestrial Probes
  - Explorers
  - Earth Sys Science Pathfinder
  - Earth Observing System
  - GOES
  - POES
  - FPOSE
  - FASM
- **Universe (10)**
  - Hubble Space Telescope
  - Navigator
  - James Webb Space Telescope
  - Spitzer Space Telescope
  - Stratospheric Observatory for Infrared Astronomy (SOFIA)
  - GLAST
  - Herschel/Planck
  - Gravity Probe B
  - Chandra X-Ray Observatory
  - Beyond Einstein
- **Missions & Systems Mgmt (3)**
  - New Millennium
  - Deep Space Mission Systems
  - Ground Network

SMD Flight Missions by Phase

Division & Theme:	Projects in: Formulation (Phase A&B)	Implementation (Phase C&D)	Operations (Phase E)
Earth-Sun Systems			
Earth Science	5	10	15
Sun-Earth Connection	2	8	13
Solar System			
Solar System Exploration	4	2	6
Mars Exploration	1	1	5
Universe			
Astronomical Origins	2	4	4
Structure & Evol of Univ.	2	3	10
Mission & Systems Mgmt			
Cross-Divisional	2	8	1

54 flight projects in formulation/development (ØA thru D)
20 flight projects in primary mission operations. (ØE)
34 flight projects in extended mission operations. (ØE-ext)

NASA Science Launches (CY05-CY10)

- US Mission on US ELV
- US Mission on DoD ELV
- Airborne Mission
- US Participation in Foreign Mission
- US Instrument on Foreign Mission
- International Constellation
- Reimbursable for NOAA

2005
- √ Deep Impact
- √MRO
- √ POES N
- GOES N
- TWINS-A
- √ Astro-E2

2006
- CALIPSO
- CloudSat
- STEREO
- New Horizons
- ST-5
- ST-6
- THEMIS
- AIM
- TWINS-B
- CINDI
- SOLAR B

2007
- Phoenix Lander
- GLAST
- DAWN
- POES N'
- GOES-P
- SOFIA
- Herschel
- Planck

2008
- NPP
- OCO
- OSTM
- Glory
- SDO
- IBEX
- Kepler
- GOES P

2009
- MSL
- SET-1
- WISE
- NuSTAR
- ST-7
- ST-8
- Aquarius

2010
- Juno
- ST-9
- LDCM
- Hydros
- GPM

Dialog with the Science Community is Critical to Success

Strategic recommendations on science priorities via the NRC
- Decadal surveys
- Focused questions of a strategic nature
- Review of strategic plans

Tactical advice on implementation of strategic priorities via
- Science committee of the NAC and subordinate groups
- Workshops with science investigator community
- Participation in major professional societies (AGU, AMS, AAS, etc)

Technical interchange on detailed requirements and engineering trades via funded Principal Investigators and Science Teams

Current Concept for NAC Support

NASA Advisory Council (25 members)

Science Cttee (5 members)

plus 4 other "cttees"

↕

Science Subcttees Executive Panel (chairs of SMD subcttees)

↑

Heliophys Subttee

Astron & Phys Subcttee

Planet Sci Subcttee

Earth Sci Subcttee

Subcttees = 12-15 members

SMD-wide Challenges

The Administrator has promised to maintain a robust and balanced science program. In return, SMD has to deliver an executable program portfolio that meets the science community's and the nation's highest priorities.

Competed smaller missions, Explorer and ESSP, have reduced budgets and cost challenges, resulting in a mission solicitation rate slower than desired

Working to improve grants processing and delivery of funds to selectees

Working to define optimal technology management approaches, using the best features of the legacy Space and Earth science models

Summary

Science organization and planning at NASA has undergone considerable change over the past year, and there is more to come

But the essentials remain the same:

- **Science questions drive mission and technology investments**
- **Science and technology research will be selected based on open, competitive processes**
- **The pace of scientific progress will demand continuous technological advancement**
- **A vast web of partnerships in science, technology and applications are required to successfully conduct Earth system science**